Center Innovation Fund: GRC CIF

Mars Li-CO_2 Batteries

Completed Technology Project (2017 - 2018)

Project Introduction

Recently, Lithium (Li)-air batteries have attracted significant attention for energy storage in electric vehicles/aircraft because this system utilizes O_2 in the air as the cathode reactant (i.e., Li-O_2 battery; Li + O_2 \u2194 Li_2O_2) and is projected to attain ultrahigh, cell specific energy that is substantially higher than conventional Li-ion batteries (1000 vs. ~260 Wh/kg at the cell level). The Mars Air Battery (MAB) is envisioned to have analogous benefits for Mars surface applications, exploiting the abundant CO_2 present in the Martian atmosphere. This Mars Air Battery (MAB) concept is a Li-CO_2 battery that reacts atmospheric CO_2 with lithium metal to produce electric power. This enables dramatically high specific energies because the CO_2 reactant is not included in the upmass of the battery system. Significantly, the MABs electrodes may also function effectively in an oxygen-rich environment (habitats, spacesuits, etc.) with no loss in battery performance. This provides the potential to design flexible, multi-use battery systems. The goal is to quantify the system-level benefits of the Mars "Air" Battery (MAB) technology at Mars atmospheric conditions (-60°C, 0.6 kPa) over a range of power requirements.

Anticipated Benefits

This technology could lead to a novel in-situ resource utilization (ISRU) energy concept which efficiently utilizes abundant CO_2 in the Mars atmosphere as the cathode reactant for lithium-based batteries (Li-CO_2 batteries). This rechargeable energy storage system has been projected to enable significant weight savings for Mars exploration missions, because a large amount of the total reactant mass (~80%) comes from the Martian CO_2 atmosphere. High energy density batteries operable in various space environments are needed for space exploration missions. Additionally, technologies that leverage in-situ resources to dramatically reduce launch mass and cost of human exploration missions are also desirable.

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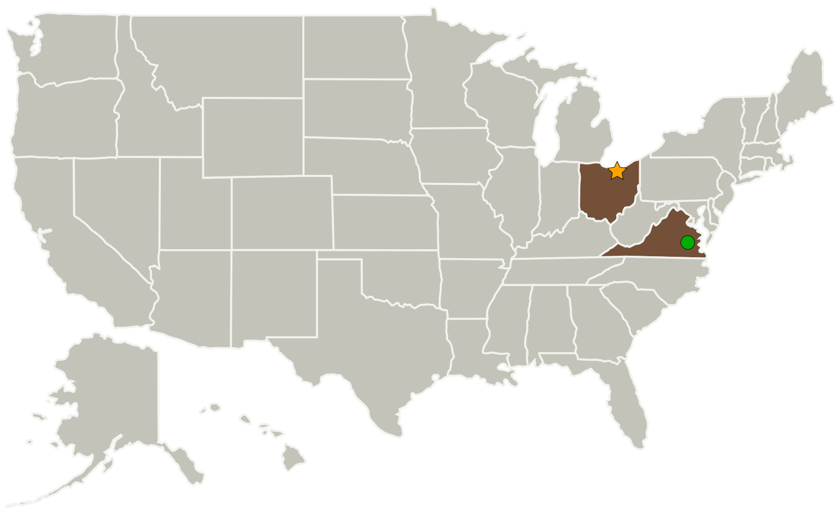
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio
●Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Ohio	Virginia

Project Transitions

▶ **October 2017:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Glenn Research Center (GRC)

Responsible Program:

Center Innovation Fund: GRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Managers:

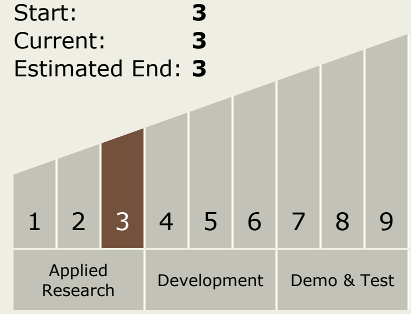
Kurt R Sacksteder
Gary A Horsham

Principal Investigator:

William C Bennett

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **3**



September 2018: Closed out

Closeout Summary: The goal of this project was to predict the specific energy that could be achieved by a practical Mars Li-CO2 surface power system. Estimates presented in this work underscore the significance of electrode loading and operating current density on the specific energy that can be achieved by the Li/CO2 couple. Technology is presently at a low technology readiness level (TRL 2-3), and further cathode development is required before the full potential of this technology can be realized.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  - └ TX03.2 Energy Storage
    - └ TX03.2.1 Electrochemical: Batteries

Target Destination

Mars